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R.H. SAUNDERS GS - BEDROCK VOID INVESTIGATION

Report No 88-318-K

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Abstract

A field investigation was undertaken to assess bedrock conditions within the dam foundation of R.H. Saunders Generating Station. The program involved borehole television camera investigations, sonar testing and velocity measurements within two boreholes (SM-6 and 88-1). Data with respect to the "void" in SM-6 was collected as well as information concerning other flowing zones.

job	file	date	report no.
44-110-575 44-116-575	844.33	January 23, 1989	88-318-K

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To Mr. O. Bernaus
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R.H. SAUNDERS GS - BEDROCK
VOID INVESTIGATION

1.0 INTRODUCTION

A field investigation was undertaken by the Rock Sciences Section (Civil Research) in conjunction with the Geotechnical and Hydraulic Engineering Department to assess bedrock conditions within the dam foundation of R.H. Saunders Generating Station. The feature of most interest was located at the 191 foot level in borehole SM-6 (chainage 23 + 40) and was reported to be up to two feet in vertical thickness and flowing at approximately 200 gpm. An additional borehole (88-1) was drilled at a distance of approximately 103 feet away to provide further information on bedrock conditions. This borehole, which was located at chainage 24 + 43, was drilled to a depth of 225 feet.

The field investigation involved examining the two boreholes with a borehole television camera, determining the lateral extent of the "void" in borehole SM-6 with sonar equipment and determining the flow rate at various water inflow zones in both boreholes with the aid of packers and a flowmeter. The field work was largely conducted during October, 1988.

2.0 EQUIPMENT AND PROCEDURES

2.1 Borehole Television Camera

The borehole television camera used was about 1.5 inches in diameter and utilized a side viewing head to enable observations in a direction perpendicular to the borehole axis. In each borehole the camera was placed inside of an aluminum cylinder to add rigidity to the equipment in potentially high flowing zones. Different diameter cylinders were required since SM-6 had a 4 inch borehole diameter and 88-1 had a 3 inch borehole diameter. The camera was fastened inside of the cylinder in such a way that only the viewing head extended past the bottom of the cylinder. Even though both boreholes were examined from top to bottom, the main emphasis was placed on examining the "void" in SM-6. The TV camera operation was conducted in both boreholes under flowing conditions.

2.2 Sonar Depth Recorder

A Lowrance X-16 sonar unit was used to obtain information with respect to the lateral extent of the "void" at the bottom of SM-6. The unit has an electronically regulated motor which drives a lightweight belt located at the right edge of the recording paper. A stylus attached to the belt marks the paper when an echo in the water is detected. The paper speed, which is controlled by a variable speed motor, allows each mark to blend into the previous one so that a composite picture of the target is made.

The transducer used was 2.5 inches in diameter and 1.0 inch in thickness and looks very similar to a hockey puck. This size configuration was selected to maximize depth penetration with an eight degree cone angle, as well as to allow the unit to be lowered in an N-sized (3 inch diameter) borehole.

2.3 Water Flow Meter

The flow meter used was an extremely accurate and sensitive liquid flow rate measuring device. The dynamic force of fluid flow, or velocity head of the approaching stream, is sensed as a drag force on a target (disc) suspended in the flow stream. The force is transmitted via a lever rod and flexure tube to an externally bonded, four active arm strain gauge bridge. This strain gauge bridge circuit translates the mechanical stress due to the sensor (target) drag into a directly proportional electrical output. Translation is linear, with infinite resolution, and is hysteresis free. The drag force itself is virtually proportional to the flow rate squared. The electrical output is virtually unaffected by variations in fluid temperature within the stated limitations of the unit.

The target flow meter was selected because of its freedom from delicate bearings, linkages and moving parts, thereby making it an accurate, rugged and maintenance free instrument with a high frequency response capable of measuring fluids with entrained air, suspended solids or highly corrosive characteristics.

The flow meter used had a diameter of 2.5 inches and a continuous full scale range from zero to 5.45 ft/sec. The accuracy of the device is 0.5 percent of full scale using the flow calibration and the repeatability and hysteresis is

0.15 percent of the reading. The flow rate at any point can be determined from the output signal at that point and the full range output from the following equation:

$$Q_I = \frac{E_I}{E_{FS}} Q_{FS}$$

where Q_I - instantaneous flow rate

Q_{FS} - full scale flow rate

E_I - instantaneous voltage output

E_{FS} - full scale voltage output

While tests were being conducted, the borehole was sealed at the top to keep the water in the borehole at a reasonably static condition. While testing the "void" at the bottom of SM-6, a rubber packer was also inflated above the zone to ensure that water wasn't flowing upwards and thereby providing false results.

Voltage readings from the velocity meter were collected on a data logger and then dumped on to a computer for storage and analysis.

3.0 BOREHOLE CAPPING AND WATER CONTROL

The most important aspect involved in testing boreholes SM-6 and 88-1 was to control the outflow of water from each hole in the inspection chamber floor. The more critical of the two holes was SM-6 because of the higher flow quantity. For the borehole camera survey and the sonar investigation, the water was left flowing from the collar in a relatively controlled manner. There was no need to stabilize the flow in order to undertake these two programs. On the contrary, each borehole was plugged at the top while water velocity measurements were carried out since a large upflow of water would have greatly affected the validity of the velocity measurements.

A PVC cross was placed above each borehole with the lower flange fastened to the concrete floor with mechanical anchors and threaded nuts. Valves were installed on the two horizontal cross pieces, while the top was left open to enable insertion of the testing equipment. A vertical PVC tee was placed on top of the cross piece to help divert the water flow from the borehole. For SM-6, a water pump was used to draw water off laterally through one of the open valves in the lower cross. The other valve was opened to allow water to flow freely under its own head pressure. In borehole 88-1, no pump was required since the flow quantity was much less. Both valves in this borehole were opened to allow water to be diverted horizontally. After each day's work and upon completion of the work, a shallow mechanical packer was placed in each borehole to seal off the flow.

For velocity measurements, a specially designed threaded end cap was placed on the tee on top of the cross piece. This end cap allowed the placement rods and the air hose (to inflate the packer) to pass through the cap and become sealed using compression bushings. The electrical cable for the flow meter and the cloth measuring tape were diverted out of the borehole through the horizontal cross piece of the tee. A plumbers' packer was placed in this opening to seal in the water and at the same time keep the placement rods from being pushed out of the hole by the water.

4.0 RESULTS AND DISCUSSION

4.1 Borehole SM-6 (Depth = 190.97 feet)

Results from the borehole television survey in SM-6 indicated that the top of the "void" appeared to be an open horizontal bedding plane. It was determined to be open 0.19 feet towards the upstream side, 0.39 feet towards the Canadian side, 0.49 feet towards the downstream side and 0.32 feet towards the American side. The top of the bedding plane is at a constant depth of 191.91 feet in all directions. The variation in bedding thickness is due to the irregular shaped cavity immediately below the bedding plane. The total depth from the top of the open bedding plane to the bottom of the cavity is approximately 1.18 feet.

Results from the sonar investigation indicated that the sonar penetrated into the open bedding plane above the cavity but not into the cavity below the open bedding plane. The sonar penetrated to a depth of 4.5 feet on the upstream side (Figure 1), 6.0 feet on the Canadian side (Figure 2), 4.5 feet on the downstream side (Figure 3), and 8.0 feet on the American side (Figure 4). Since the "void" was reported to be in the order of two feet wide, the sonar equipment used was selected for maximum, rather than minimum penetration. This means that the equipment used provided erratic reading for distances less than 3.0 feet in the radial direction. Since the values obtained in the cavity below the open bedding plane were erratic, it can be assumed that the cavity is less than 3.0 feet in all directions from the borehole axis. Television camera observations confirm these results since the walls of the cavity were clearly visible in all directions.

With the borehole sealed at the top and the "void" sealed with a packer immediately above it, velocities were measured in twelve directions within the open bedding plane area. The velocities are shown in plan view in Figure 5. Positive values indicate flow into the borehole, while negative values indicate flow away from the borehole. The predominant inflow is 0.19 ft/sec at 20 degrees from the upstream side towards the Canadian side, while the predominant outflow is -0.38 ft/sec at approximately 20 degrees from the downstream side towards the American side. By releasing the packer above the "void" and determining velocities again, it was noted that no significant changes in results occurred. On the contrary, by removing the cap at the collar of the hole, the flow increased and came into the borehole from all

directions (Figure 6). The flow velocity was 0.59 ft/sec from the upstream side, 0.58 ft/sec from the Canadian side, 0.68 ft/sec from the downstream side and 0.64 ft/sec from the American side.

4.2 Borehole SM-6 (Depth = 138.75 feet)

The borehole television survey revealed a bedding plane open to 0.33 inches, which was flowing into the borehole. The flowing water caused the camera to move back and forth at this location. A small piece of rock was observed being washed into the borehole from the open bedding plane. The zone in which this open bedding plane was found appeared to be quite solutioned.

Eight velocity readings were taken in this zone with both the hole capped and a packer set just above the testing zone. The velocities are shown in Figure 7. The predominant inflow was approximately 0.28 ft/sec at 20 degrees from the downstream side towards the Canadian side, while the predominant outflow was approximately 0.27 ft/sec at 20 degrees from the upstream side towards the American side. No significant velocity changes occurred when the packer above the zone was deflated.

4.3 Borehole 88-1 (Depth = 157.63 feet)

Borehole television camera investigations revealed a bedding plane open to 1.5 inches at a depth of 157.63 feet in borehole 88-1. With the borehole open at the top (ie flowing), particles were noted flowing into the borehole from the downstream side and moving upwards. From the bottom of the borehole at a depth of approximately 225 feet up to the depth of this particular feature, debris was noted falling towards the bottom of the hole. This suggests that no significant inflow of water exists below the 157.63 foot mark. This also indicates that no water is coming from the 191 foot level in 88-1, which is the equivalent depth level to the "void" in SM-6.

With the borehole sealed at the top, eight velocity measurements were made in this zone (Figure 8).

All locations indicate water flow into the borehole at a rate ranging from 0.31 to 0.37 ft/sec. It can be concluded that water is flowing in equally from all directions (ie no predominant direction), since the accuracy of the flow measuring device is $\pm$ 0.5% of full scale (ie $\pm$ 0.03 ft/sec).

With the borehole open at the top (ie flowing), the predominant inflow direction is at 20 degrees from the Canadian side towards the upstream side (Figure 9). The flow was into the borehole from all directions (maximum = +.50 ft/sec) except for the American side, where flow was out of the borehole at -.23 ft/sec.

4.4 Borehole 88-1 (Depth = 128.37 feet)

The borehole television survey revealed a void open to 0.44 feet, which had water flowing into the borehole. The flowing water caused the camera to move back and forth at this location.

Eight velocity readings were taken in this zone with the borehole sealed at the top (Figure 10). All locations indicate water flow into the borehole at a rate ranging from 0.30 to 0.38 ft/sec. It can be concluded that water is flowing in equally from all directions (ie no predominant direction), within the stated accuracy of the flow measuring device.

With the borehole open at the top (ie flowing), the predominant inflow direction is at 35 degrees from the downstream side towards the Canadian side (Figure 11). The water flowed into the borehole from all directions with the maximum recorded from the downstream side (0.93 ft/sec) and the minimum from the upstream side (0.51 ft/sec).

4.5 Borehole 88-1 (Depth = 47.84 feet)

The borehole television survey revealed a void open to 0.55 feet, which was flowing into the borehole. The flowing water caused the camera to move back and forth at this depth. Eight velocity readings were taken in this zone with the borehole sealed at the top (Figure 12). All locations indicate water flow into the borehole at a rate ranging from 0.34 to 0.40 ft/sec. It can be concluded that water is flowing in equally from all directions (ie no predominant direction), within the stated accuracy of the flow measuring device.

With the borehole open at the top (ie flowing), the predominant inflow direction is at 45 degrees from the upstream side towards the American side (Figure 13). The water flowed into the borehole from the upstream and American sides (maximum = .77 ft/sec) and out of the borehole on the Canadian and downstream sides (maximum = -.99 ft/sec).

5.0 TELEVISION CAMERA SURVEY

Both boreholes SM-6 and 88-1 were scanned using the borehole television camera from bottom to top. The holes were recorded on video cassettes. Borehole logs based on TV camera investigations are included in Appendix A of this report.

6.0 SUMMARY

1. The "void" at the 191 foot level in SM-6 consists of an open bedding plane overlying a cavity of finite lateral extent.

2. The open bedding plane at the 191 foot level was traced to a maximum lateral extent of 8 feet from the borehole axis using sonar. The restrictions on this value were due to the size of the opening and the cone angle of the transducer.

3. The maximum vertical width of the bedding plane at the 191 foot level was 0.49 feet in the downstream direction while the minimum vertical width was 0.19 feet in the upstream direction. The overall width of the bedding plane and underlying cavity was 1.18 feet.

4. The maximum horizontal extent of the cavity is 3 feet based on sonar results and probably less based on television camera observations.

5. The predominant flow direction at the 190.97 foot level was from the upstream side (0.19 ft/sec) to the downstream side (-0.38 ft/sec).

6. Neither a flow rate or a "void" was found in borehole 88-1 at a similar depth (ie ~191 feet) to the "void" found in borehole SM-6.

7. Other open zones with flowing water were found at depth 138.75 feet in borehole SM-6, and depths 157.63 feet, 128.37 feet, and 47.84 feet in borehole 88-1.

7.0 RECOMMENDATIONS

It is recommended that monitoring of the foundation be continued on a regular basis using techniques such as those described in this report. It would also be prudent to continue the development and assessment of techniques to define the extent of underground openings. A possible candidate for this application would be an underwater laser system capable of working in N-sized boreholes.

8.0 CONCLUSION

A field investigation was undertaken at R.H. Saunders GS to assess bedrock conditions within the dam foundation. The program involved examining boreholes SM-6 and 88-1 with a borehole camera and testing specific zones with sonar and velocity measuring equipment. Information with respect to the "void" in SM-6 was collected to better define its vertical and lateral extent and flow rate. Information with respect to other flowing zones in the two boreholes was also documented.

9.0 ACKNOWLEDGMENTS

We wish to thank Mr. Brian Andress for his contribution to this program and the staff at R.H. Saunders Generating Station for the excellent support and co-operation which they provided during the investigation program.

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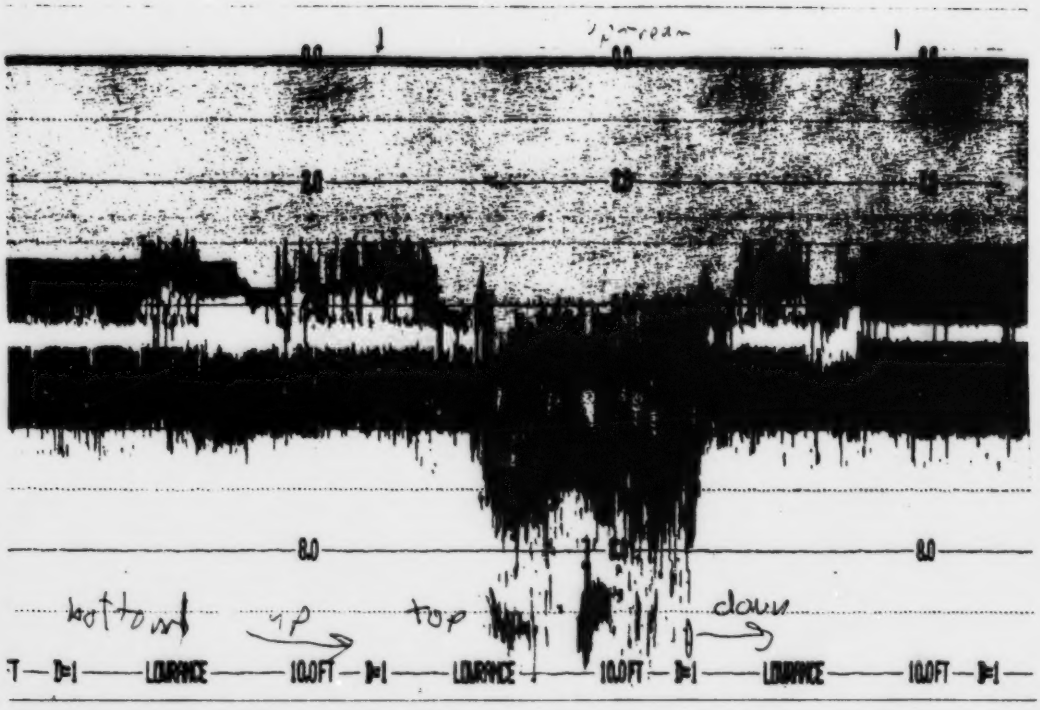


FIGURE 1
Sonar Trace of Open Bedding Plane Above Cavity
At 190.97 Feet In SM-6 (Upstream Side)

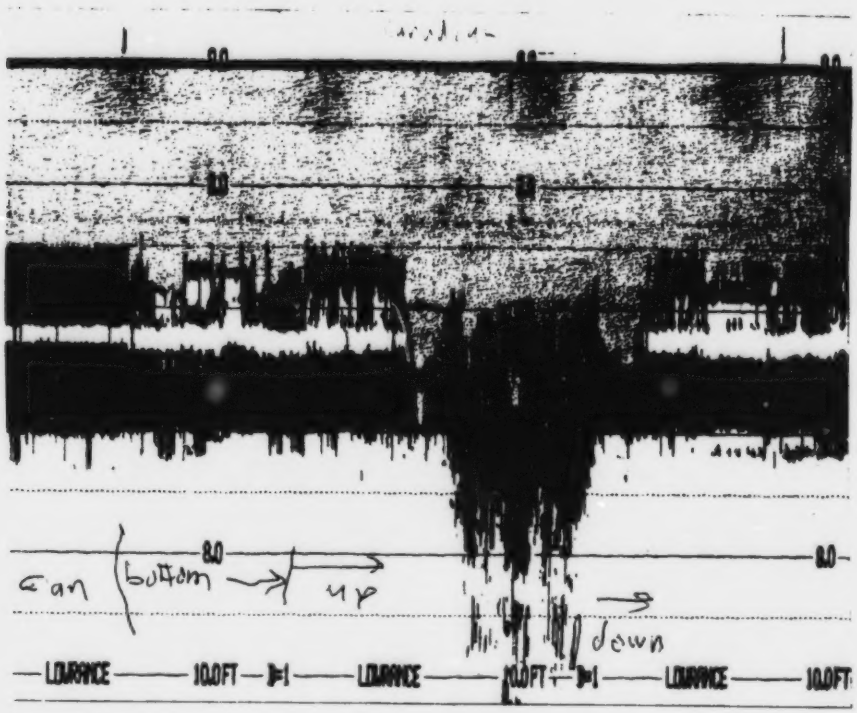


FIGURE 2
Sonar Trace of Open Bedding Plane Above Cavity
At 190.97 Feet In SM-6 (Canadian Side)

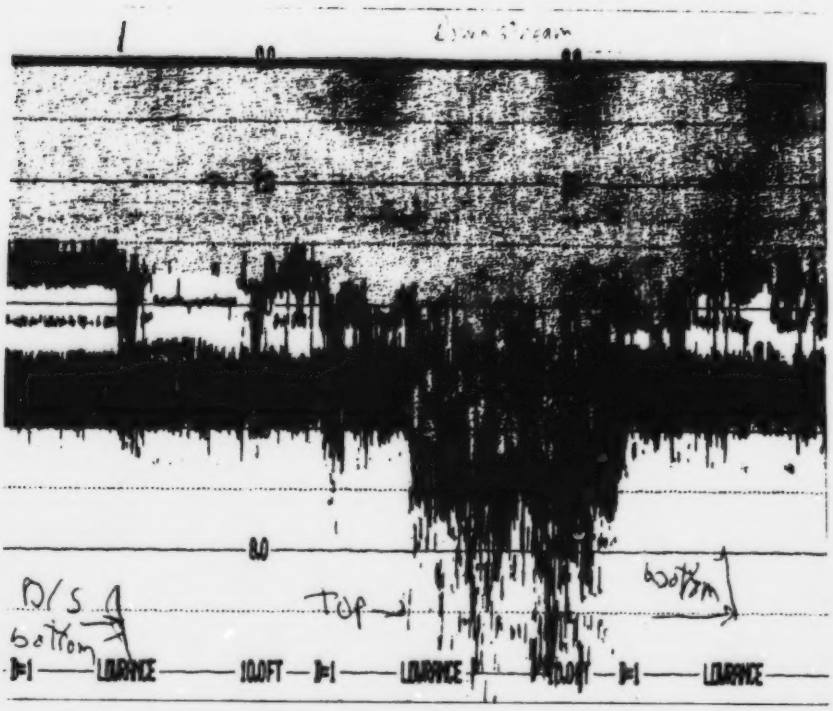


FIGURE 3
Sonar Trace of Open Bedding Plane Above Cavity
At 190.97 Feet In SM-6 (Downstream Side)

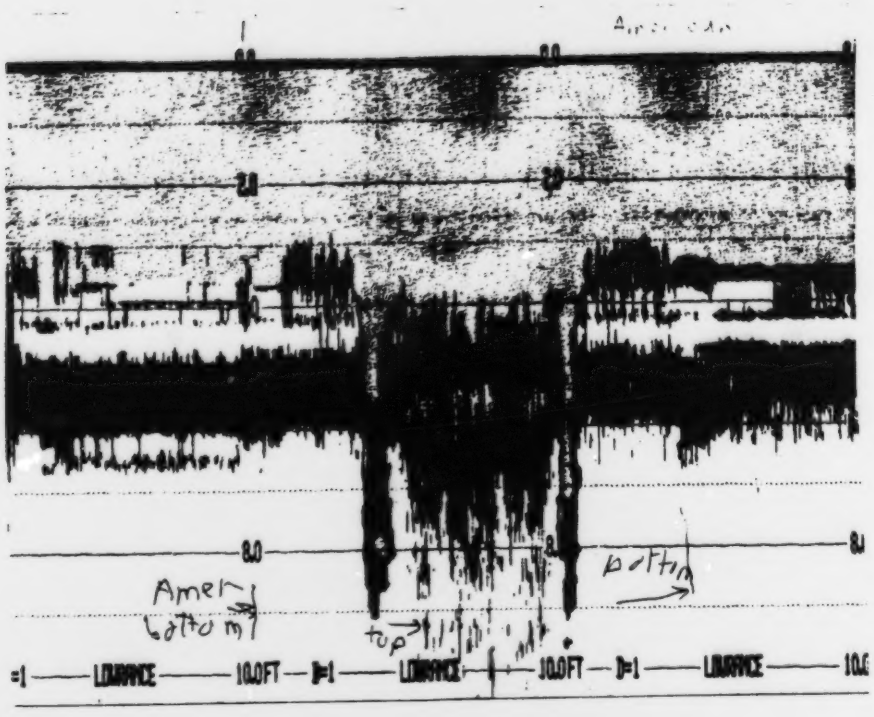
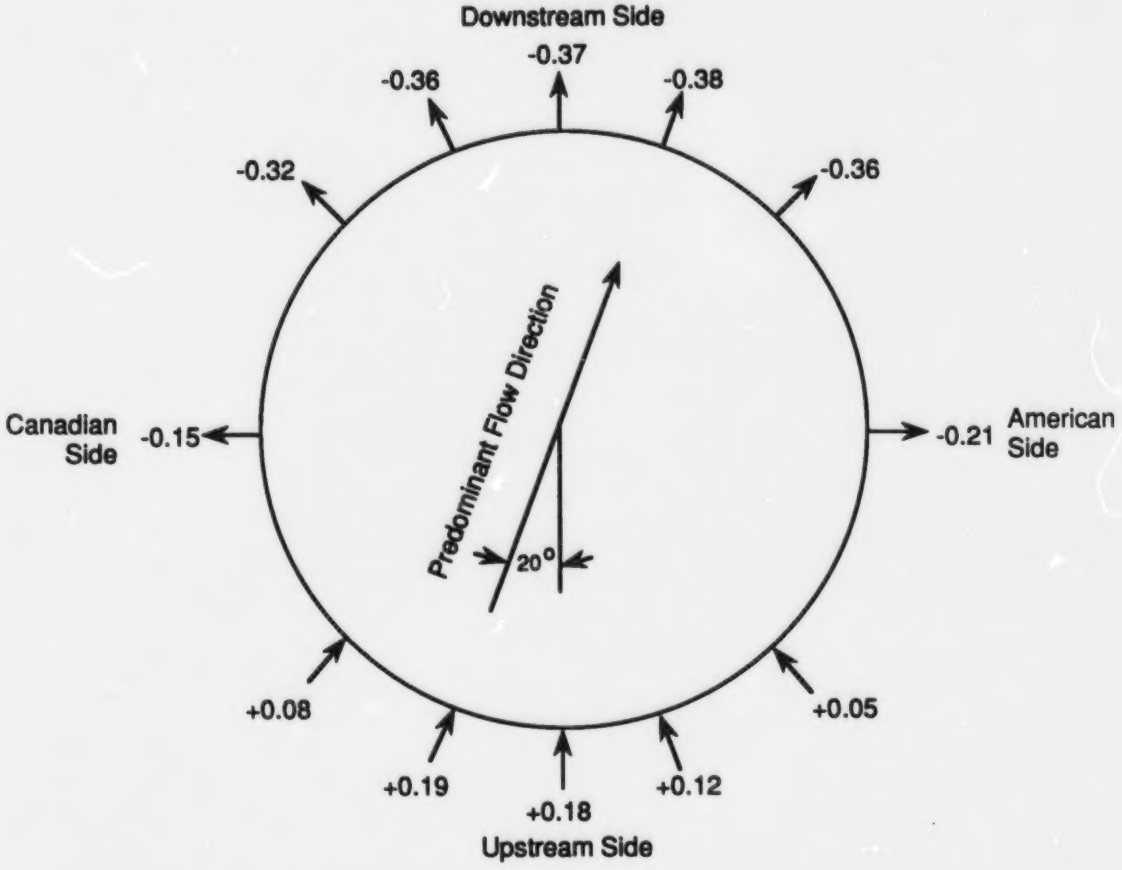


FIGURE 4
Sonar Trace of Open Bedding Plane Above Cavity
At 190.97 Feet In SM-6 (American Side)



Notes:

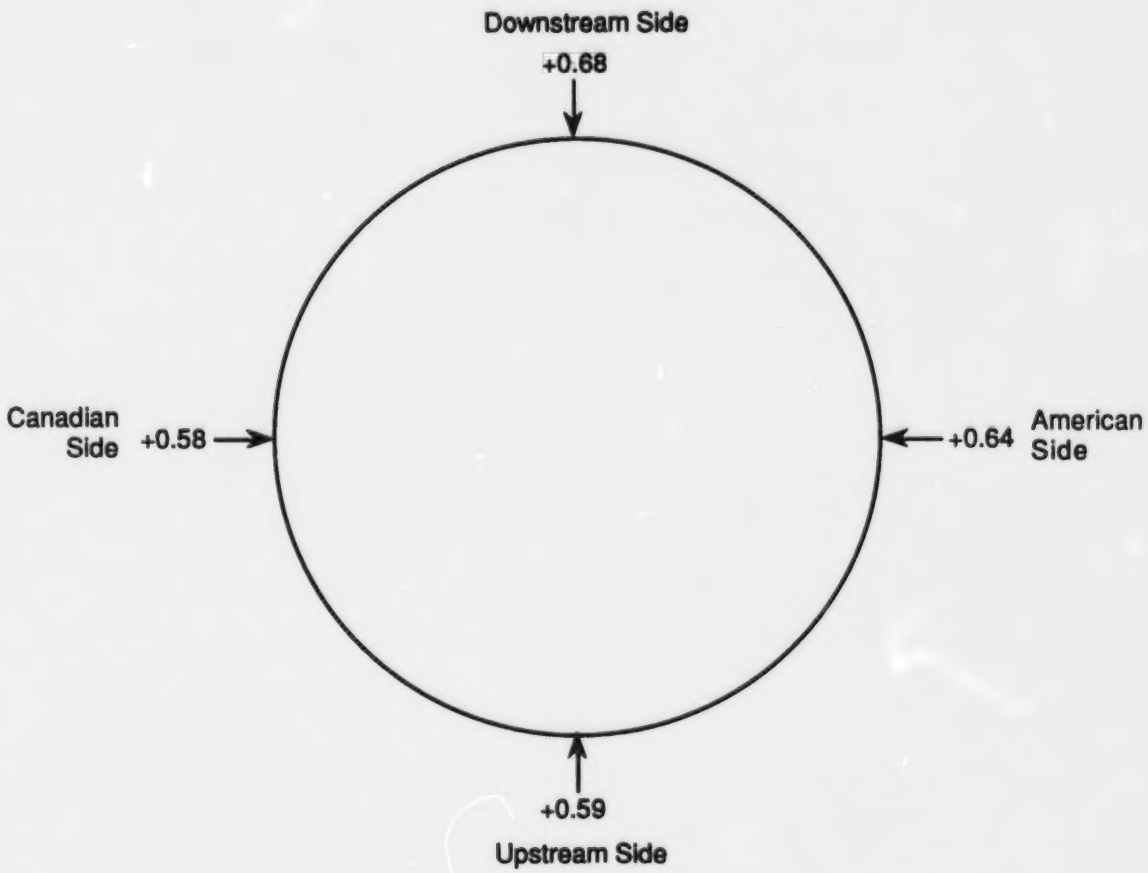
1. Borehole Sealed at Top
2. Zone Sealed with Packer Above Void Area
3. Flow Into Borehole is Positive (ft/sec)
4. Flow Out of Borehole is Negative (ft/sec)

FIGURE 5

PLAN VIEW SHOWING FLOW RATES AND DIRECTIONS AT 190.97 FEET IN BOREHOLE SM-6 (SEALED AT TOP)

88-318

Koopmans Fig.5
Mcwitcz



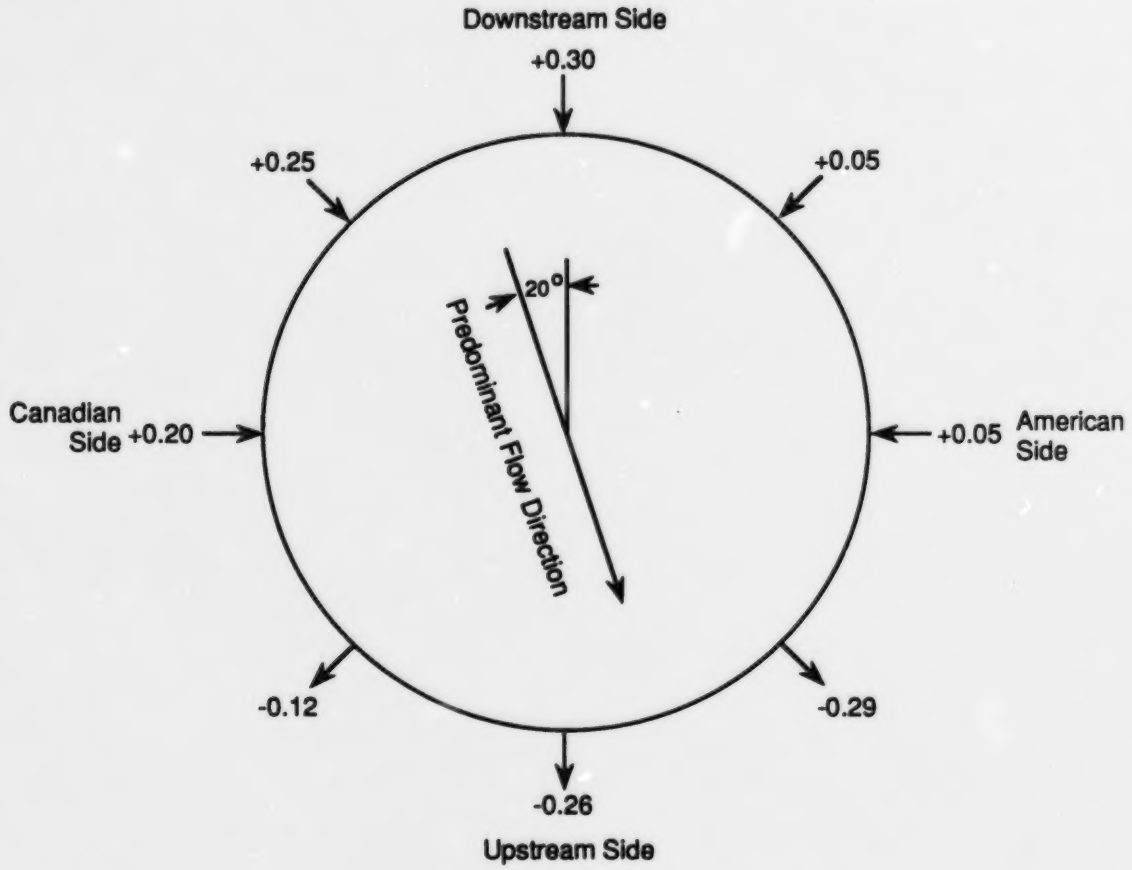
Notes:

1. Borehole Open at Top
2. Flow into Borehole is Positive (ft/sec)

FIGURE 6

PLAN VIEW SHOWING FLOW RATES AND DIRECTIONS AT 190.97 FEET IN BOREHOLE SM-6 (SEALED AT TOP)

88-318
KOOPMANS Fig.6
McWitcz



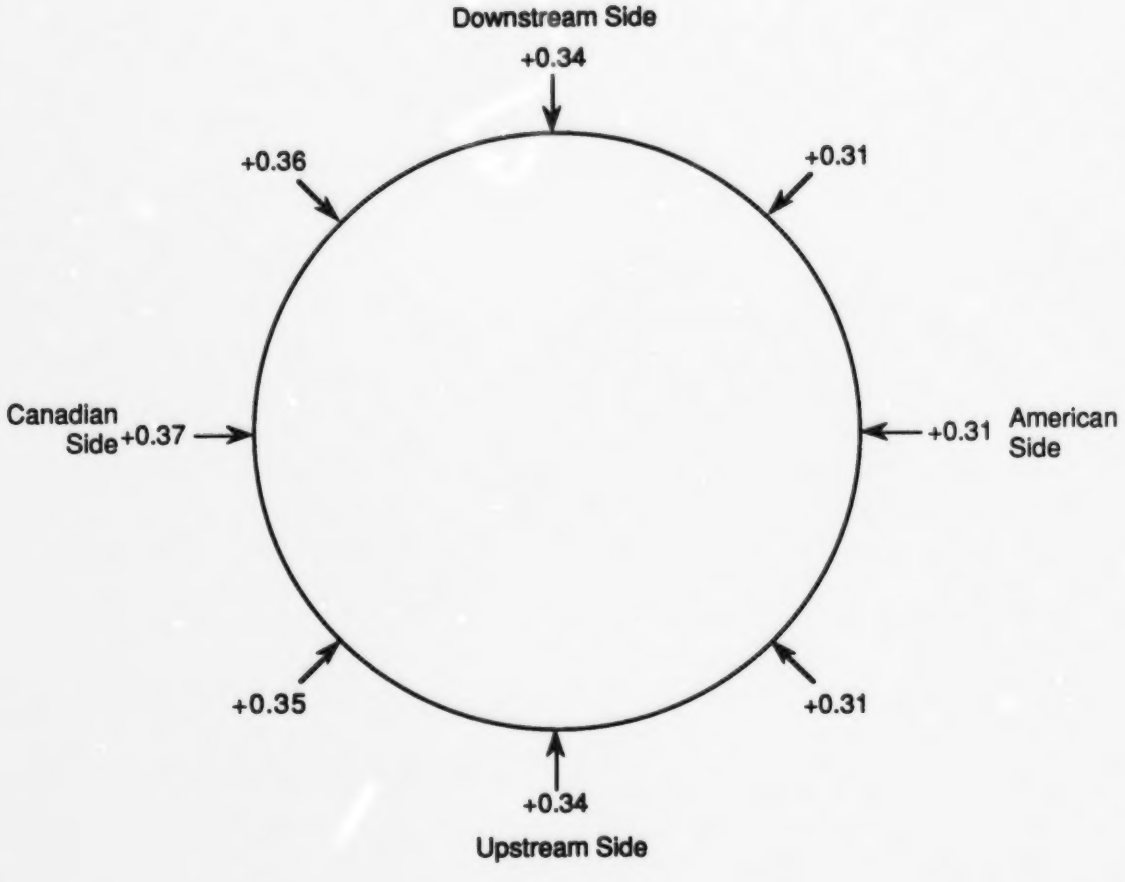
Notes:

1. Borehole Sealed at Top
2. Packer Set Above Testing Zone
3. Flow Into Borehole is Positive (ft/sec)
4. Flow Out of Borehole is Negative (ft/sec)

FIGURE 7

PLAN VIEW SHOWING FLOW RATES AND DIRECTIONS AT 138.75 FEET IN BOREHOLE SM-6 (SEALED AT TOP)

88-318
Koopmans Fig.7
McWitcz

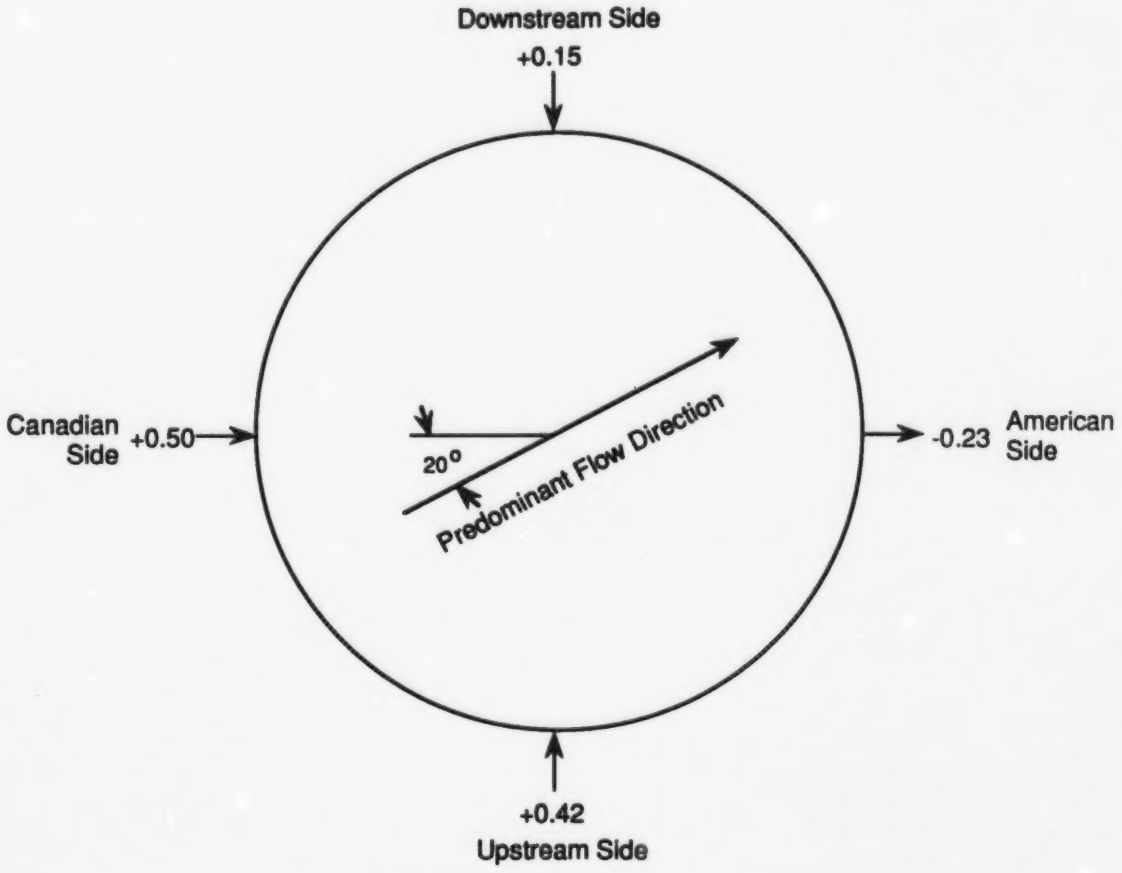


Notes:

1. Borehole Sealed at Top
2. Flow Into Borehole is Positive (ft/sec)

FIGURE 8
PLAN VIEW SHOWING FLOW RATES AND DIRECTIONS AT 157.63 FEET IN BOREHOLE 88-1 (SEALED AT TOP)

88-318
KOOPMANS Fig.8
MCWITCZ



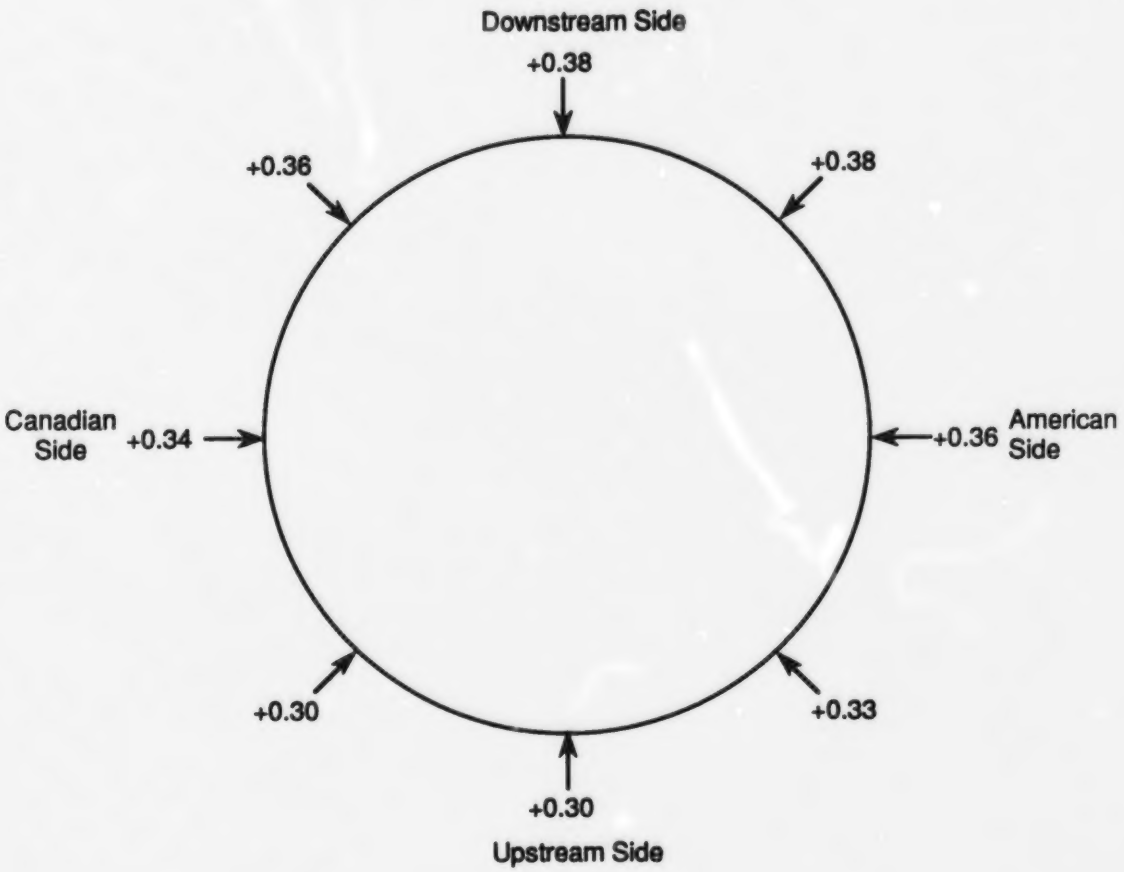
Notes:

1. Borehole Open at Top
2. Flow Into Borehole is Positive (ft/sec)
3. Flow Out of Borehole is Negative (ft/sec)

FIGURE 9

PLAN VIEW SHOWING FLOW RATES AND DIRECTIONS AT 157.63 FEET IN BOREHOLE 88-1 (OPEN AT TOP)

88-318
KOOPMANS Fig.9
McWitcz



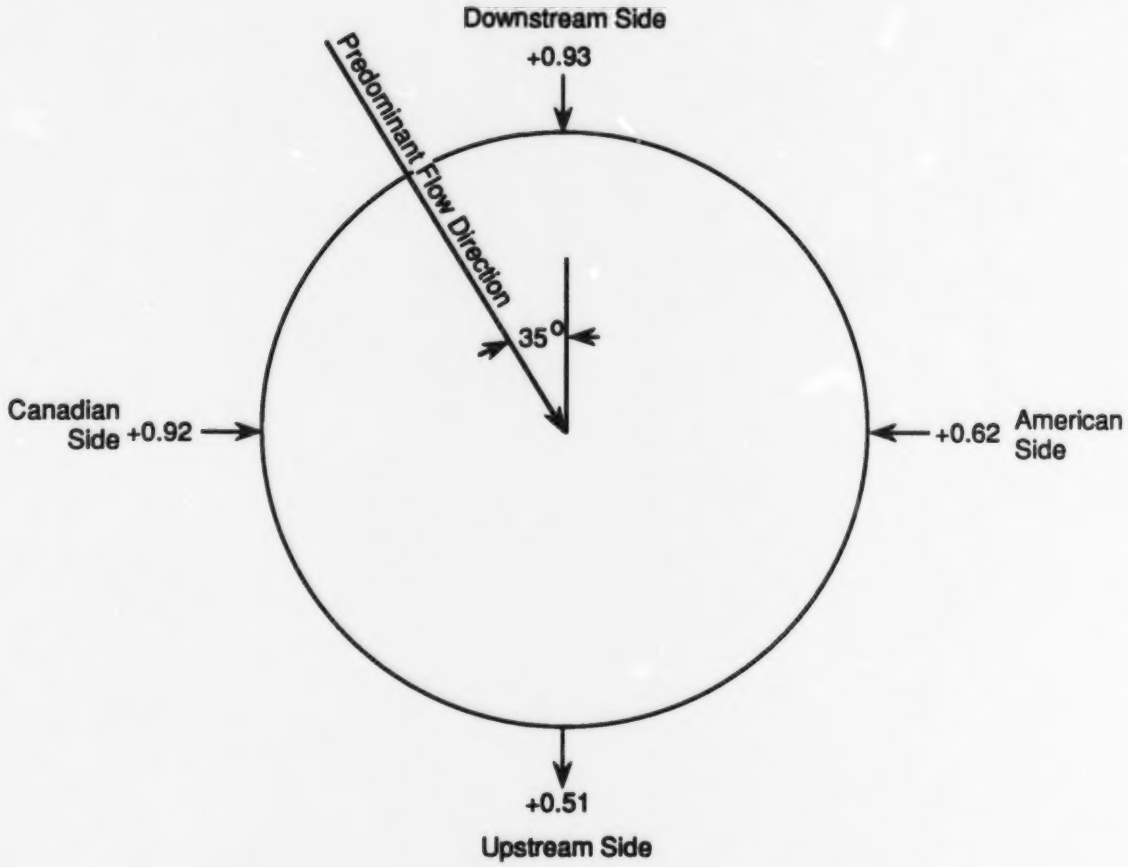
Notes:

1. Borehole Sealed at Top
2. Flow Into Borehole is Positive (ft/sec)

FIGURE 10

PLAN VIEW SHOWING FLOW RATES AND DIRECTIONS AT 128.37 FEET IN BOREHOLE 88-1 (SEALED AT TOP)

88-318
KCOPMNSFig10
MTwitz



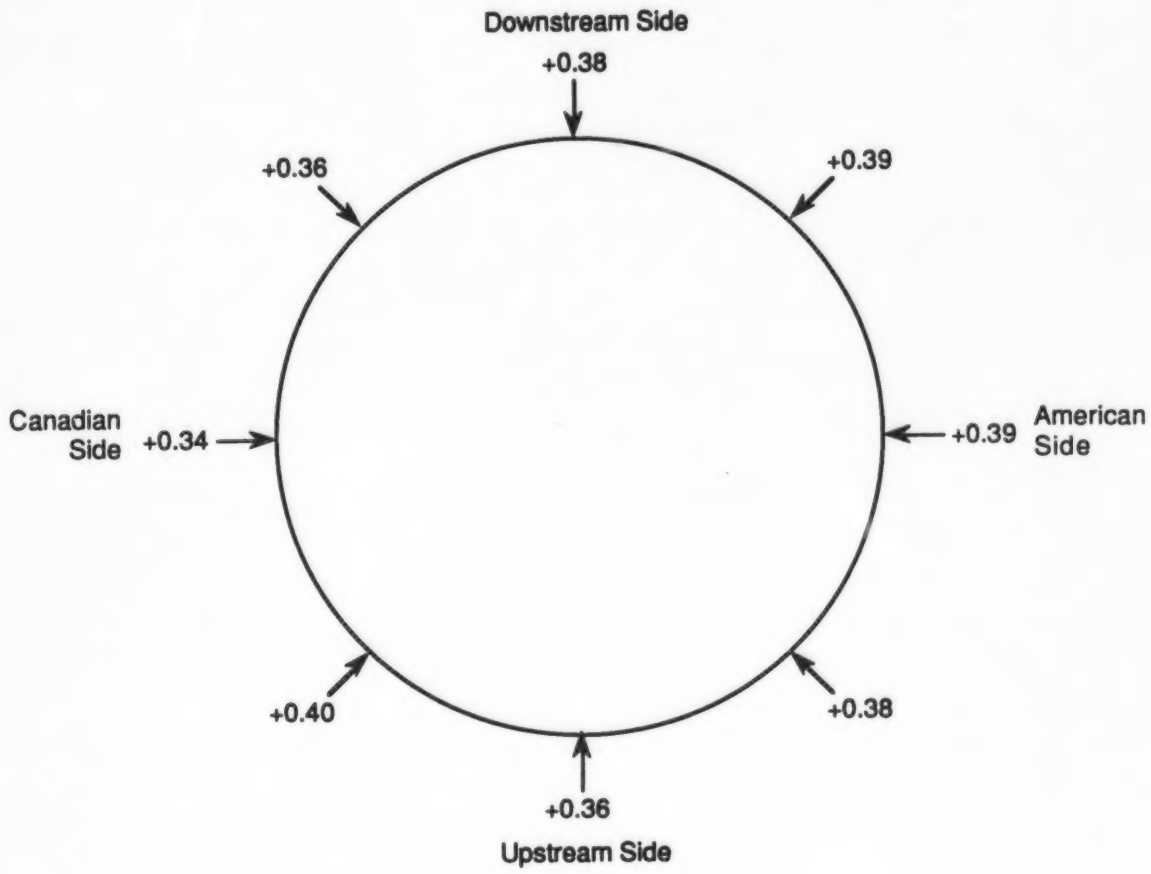
Notes:

1. Borehole Open at Top
2. Flow Into Borehole is Positive (ft/sec)

FIGURE 11

PLAN VIEW SHOWING FLOW RATES AND DIRECTIONS AT 128.37 FEET IN BOREHOLE 88-1 (OPEN AT TOP)

88-318
KOOPMANS Fig.11
McWitcz



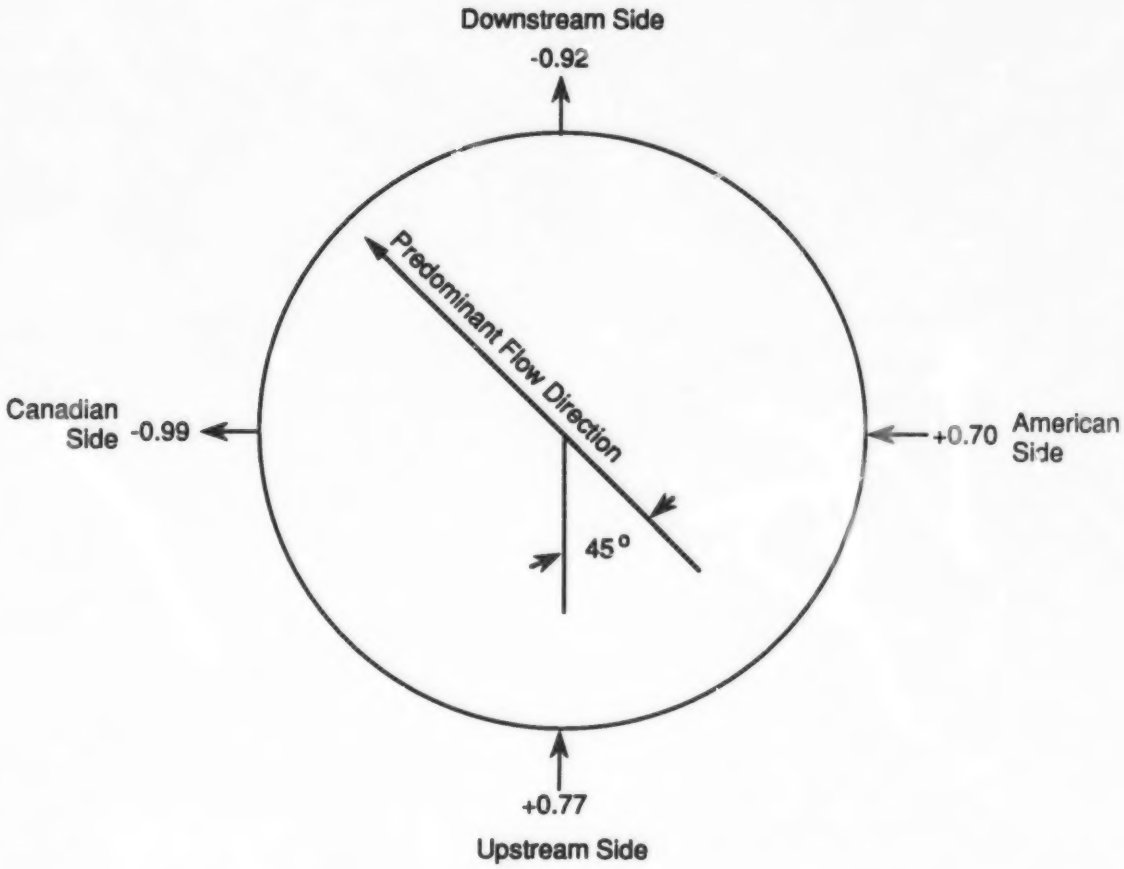
Notes:

1. Borehole Sealed at Top
2. Flow Into Borehole is Positive (ft/sec)

FIGURE 12

PLAN VIEW SHOWING FLOW RATES AND DIRECTIONS AT 47.84 FEET IN BOREHOLE 88-1 (SEALED AT TOP)

88-318
KOOPMANS Fig.12
McWitcz



Notes:

1. Borehole Open at Top
2. Flow Into Borehole is Positive (ft/sec)
3. Flow Out of Borehole is Negative (ft/sec)

FIGURE 13

PLAN VIEW SHOWING FLOW RATES AND DIRECTIONS AT 47.84 FEET IN BOREHOLE 88-1 (OPEN AT TOP)

88-318

KOOPMANS Fig.13
McWitcz

APPENDIX A

R.H. SAUNDERS GENERATING STATION
BOREHOLE TELEVISION CAMERA LOG

Borehole: SM-6 Date: September 15, 1988

Depth (ft)	Description
192.21	-bottom of borehole
191.91	-bottom of cavity (upstream side)
190.92	-bottom of open bedding plane (upstream side)
190.73	-top of open bedding plane (upstream side)
191.91	-bottom of cavity (downstream side)
191.22	-bottom of open bedding plane (downstream side)
190.74	-top of open bedding plane (downstream side)
191.92	-bottom of cavity (Canadian side)
191.11	-bottom of bedding plane (Canadian side)
190.72	-top of open bedding plane (Canadian side)
191.90	-bottom of cavity (American side)
191.05	-bottom of bedding plane (American side)
190.74	-top of open bedding plane (Canadian side)
189.67	-void open 1.0 inches
189.02	-void open 1.0 inches
188.22	-double fracture (each open 0.10 in)
187.87	-void open 1.5 in
187.46	-fracture (open 0.33 in)
186.80	-reference point
186.50	-double fracture (each open 0.10 in)
185.80	-double fracture (open 0.50 in)

BOREHOLE SM-6

Depth (ft)	Description
185.21	-fracture (open 0.10 in)
184.88	-fracture (open 0.10 in)
184.80	-fracture (open 0.10 in)
184.00	-double fracture (open 0.25 in)
183.72	-irregular fracture (open 0.25 in)
182.79	-four horizontal fractures (open 0.25 in)
182.34	-fracture (open 0.33 in)
181.62	-clay seam - open at top - (1.0 in thickness)
181.30	-fracture (open 0.25 in)
180.80	-double fracture (open 0.33 in)
180.51	-fracture (open 0.50 in)
180.04	-reference point
179.93	-double fracture (each open 0.25 in)
179.23	-fracture (open 0.33 in)
179.02	-irregular void (open up to 1.0 in diameter)
178.88	-irregular fracture (open 0.25 in)
178.42	-fracture (open 0.33 in)
178.11	-fracture (open 0.25 in)
177.93	-double fracture (each open 0.25 in)
177.79	-double fracture (each open 0.33 in)
177.50	-double fracture (each open 0.10 in)
177.25	-irregular fracture (open 0.67 in)
176.79	-fracture (open 0.67 in)
176.36	-three horizontal fractures (open 0.5 in)
175.98	-irregular fracture (open 0.33 in)
175.46	-fracture (open 0.25 in)
175.03	-irregular fracture (open 0.25 in)
174.45	-irregular fracture (open 0.25 in)

BOREHOLE SM-6

Depth (ft)	Description
174.03	-irregular fracture (open up to 0.5 in)
173.49	-reference point
?	-fracture (open)
167.32	-fracture (open)
?	-fracture (open)
?	-fracture (open)
?	-fracture (open)
166.73	-reference point
?	-heavily fractured zone
?	-fracture
?	-fracture
163.39	-bottom of fractured zone - rehealed
153.61	-reference point
152.07	-irregular fracture (open)
?	-fracture
147.64	-fracture (open)
147.05	-reference point
147.05	-fracture (open)
?	-fracture (open)
?	-fracture (open)
140.49	-reference point
140.49	-fracture (open)
?	-fracture (open)
?	-fracture (open)
?	-heavily fractured zone
138.98	-fracture open 0.33 inch in solutioned zone - water flowing into borehole - small piece of rock seen washed into borehole

BOREHOLE SM-6

Depth (ft)	Description
136.06	-gypsum with dolomite (brecciated appearance)
133.92	-reference point
131.56	-fractures (open) vertical and horizontal
?	-fracture (open)
?	-fracture (open)
?	-fracture (open)
?	-fracture (open)
107.68	-reference point
?	-fracture (open)
101.12	-reference point
?	-fracture (slightly open)
?	-fracture (open)
?	-fracture (slightly open)
?	-fracture (open 1.0 in)
94.55	-reference point
?	-fracture (slightly open)
?	-fracture (slightly open)
?	-fracture (open)
?	-fracture (slightly open)
87.99	-reference point
?	-fracture (open 0.67 in)
86.94	-fracture (open)
?	-fracture (tight)
?	-fracture (slightly open)
87.99	-reference point
?	-fracture (open 0.67 in)
86.94	-fracture (open)
?	-fracture (tight)

BOREHOLE SM-6

Depth (ft)	Description
?	-fracture (slightly open)
87.99	-reference point
?	-fracture (open 0.67 in)
86.94	-fracture (open)
?	-fracture (tight)
?	-fracture (slightly open)
81.43	-reference point
78.94	-fracture (open 0.5 in) - water flowing into borehole
?	-double fracture
?	-fracture (open)
?	-tight fracture (45°)
74.87	-reference point
?	-fracture (slightly open)
?	-broken fracture zone
?	-gypsum bed (approx. 1.5 ft in thickness)
?	-fracture (slightly open)
?	-fracture (open)
?	-vuggy zone
?	-fracture
68.31	-reference point
?	-fracture (open)
?	-fracture (open)
?	-fracture zone
61.75	-reference point
?	-fracture (open) -45°
57.74	-fracture (slightly open)
?	-angular fracture (open) - sub-horizontal
?	-angular fracture - open
?	-fracture - open

BOREHOLE SM-6

55.18	-reference point
?	-intersecting joints (vertical and 60° from horizontal) - slightly open
?	-fracture (tight)
?	-gypsum layer
?	-fracture (slightly open)
?	-curved fracture (60° from horizontal)
?	-double fracture
?	-fracture (slightly open)
?	-fracture (slightly open)
?	-fracture (slightly open)
?	-fracture (slightly open)
?	-fracture (open)
48.62	-reference point
47.57 (approx)	-contact between gypsum and dolomite
?	-sub-horizontal fracture (slightly open)
46.75 (approx)	-gypsum layer
?	-sub-horizontal fracture
?	-fractured zone all angles
45.67	-fracture zone (open)
?	-fracture zone (open 4.0 in)
?	-double fracture (both open)
42.06	-reference point
?	-fracture (slightly open)
?	-irregular fracture (slightly open)

BOREHOLE SM-6

40.55	-fracture (open 2.0 in) solutioned
?	-fracture (tight)
?	-fracture (open 0.33 in)
?	-fracture (open)
?	-fracture (open)
?	-fracture (slightly open)
?	-irregular fracture (slightly open)
?	-irregular fracture (slightly open)
?	-irregular fracture (open)
?	-fracture (tight)
?	-fracture (slightly open)
35.50	-reference point
32.94	-fracture (open 6 in) -upstream most open - rubbled appearance
?	-fracture (open) - 10° from horizontal
?	-fracture (tight) - 35° from horizontal
?	-fracture (open 0.33 in)
28.94	-reference point
?	-irregular fracture
?	-fracture (slightly open)
?	-fracture (slightly open)
?	-fracture (slightly open)
?	-fracture (slightly open)
?	-fracture (open 0.33 in)
23.03	-rock/concrete interface (tight)
22.38	-reference point
15.81	-reference point
9.25	-reference point
0.00	-concrete floor - inspection chamber

R.H SAUNDERS GENERATING STATION
BOREHOLE TELEVISION CAMERA LOG

Borehole: 88-1 Date: October 16, 1988

Depth (ft)	Description
223.80	-bottom of borehole
222.12	-horizontal fracture (open 0.10 in)
220.15	-reference point
219.62	-intersecting fracture (open 0.25 in)
218.97	-gypsum interface (lower)
216.69	-fracture (open 0.20 in)
215.48	-irregular fracture (open 0.20 in)
213.77	-reference point
208.96	-irregular fracture
208.12	-gypsum interface (upper)-irregular
207.12	-reference point
206.55	-tight fracture
205.50	-tight fracture
202.17	-slightly open fracture
200.67	-reference point
194.79	-fracture (open 0.10 in)
193.90	-reference point
190.28	-top of intensely fractured zone to ~194.79 ft
188.54	-fracture (open 0.25 in)
187.40	-reference point
187.00	-fracture (open 0.25 in)
185.95	-fracture (open 0.13 in)
186.40	-fracture (open 0.25 in)
185.56	-fracture (open 0.13 in)
181.60	-voids to 0.13 in diameter
181.50	-reference point

Borehole: 88-1

Depth (ft)	Description
178.73	-void 0.50 inch in diameter
178.08	-gypsum filled vug (open to 1 in)
177.28	-void (open 0.25 in)
175.43	-fracture (open 0.25 in)
174.76	-fracture (open 0.25 in)
174.22	-reference point
172.58	-fracture (open 0.25 in)
171.75	-fracture (open 0.25 in)
171.31	-fracture (open 0.50 in)
171.12	-fracture (open 0.33 in)
171.03	-fracture (open 0.33 in)
170.95	-void (open 2 in)
170.70	-fracture (open 0.5 in)
170.30	-fracture (open 0.5 in)
168.70	-fracture (open 0.1 in)
167.80	-fracture (open 0.1 in)
167.80	-reference point (particles fall down hole)
166.97	-fracture (open 0.25 in)
164.23 to 164.00	-open void
161.15	-reference point
157.63	-void open 1.5 in - making water (particles entering borehole from D/S side)
154.70	-reference point
148.42	-vuggy zone (open to 0.67 in)
147.95	-reference point
145.68	-two open voids (0.5 in diameter)
141.63	-reference point
140.57	-fracture (slightly open)
139.55	-fracture (open 0.5 in)
139.30	-void (open 0.5 in)

Borehole: 88-1

Depth (ft)	Description
139.0	-fracture (open 0.25 in)
138.64	-void (open 0.5 in)
138.54	-void (open to 0.67 in)
138.33	-void (open to 0.25 in)
137.96	-voids (open to 1.5 in)
137.83	-fracture intersects void at 137.96 ft
137.64	-void open to 0.5 in
137.45	-void open to 2.0 in (irregular)
136.60	-vuggy zone
135.43	-void open to 2.0 in - vuggy
134.80	-reference point
133.30	-two intersecting fractures (open 0.25 in)
133.20	-fracture (open 0.5 in) irregular
131.60	-fracture (open 0.25 in)
130.00	-fracture (open 0.67 in)
129.30 to 129.45	-void open to 2.0 in - solutioned
128.90	-void open to 1.25 in
128.15 to 128.59	-open void - making water
128.40	-reference point
122.47	-void open to 1.0 in - irregular
121.70	-reference point
118.50	-slightly open fracture
115.40	-reference point
108.60	-reference point
101.90	-vuggy zone (open to 0.5 in)
99.60	-fracture (open 0.25 in)
95.85	-reference point
94.35	-fracture (open 0.25 in) -irregular
89.00	-reference point
82.40	-reference point
79.14	-reference point

Borehole: 88-1

Depth (ft)	Description
78.80	-void open to 0.5 in - irregular
75.70	-reference point
74.00	-fracture (open 0.25 in)
72.24	-double fracture (each open 0.25 in)
69.98	-void open to 0.5 in
69.82	-circular void open to 0.25 in
69.16	-reference point
67.75	-void open to 1.0 in
64.43	-fracture (open 0.5 in)
62.70	-reference point
58.13	-vuggy zone open to 1.0 in
57.90	-void open to 2.0 in
57.58	-fracture open to 0.10 in
56.04	-reference point
53.50	-void open to 0.5 in - solutioned
52.19	-void open to 0.5 in - irregular
51.82	-void open to 0.25 in - solutioned
51.51	-void open to 2.0 in - solutioned
51.13	-top of solutioned zone
50.90	-fracture (open 0.25 in)
49.67	-void open 0.10 in
49.67	-reference point
49.47	-fracture (open 0.25 in)
48.84	-fracture (open 0.25 in)
47.56 to 48.11	-void open 0.55 ft - making water
47.03	-fracture (open 0.25 in)
46.32	-void open 0.5 in - solutioned
46.03	-void open 0.25 in
44.53	-void open 1.0 in

Borehole: 88-1

Depth (ft)	Description
43.04	-reference point
38.64	-void open 1.0 in
37.84	-fracture (open 0.5 in)
36.34	-reference point
29.93	-reference point
29.20	-fracture (open 0.25 in)
28.52	-fracture (open 0.10 in)
28.10	-fracture (open 0.25 in)
25.52	-inclined fracture (open 0.10 in)
24.20	-bedrock/concrete contact
23.45	-reference point
16.78	-reference point
10.12	-reference point
0.00	-concrete floor - inspection chamber